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(54) Low-pressure CVD Method

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**Specifications**

1. Name of Invention: Low-pressure CVD Method

## 2. Scope of Patent Application

(1) In a low-pressure CVD method whereby an impurity reaction gas made up of a raw-material gas with silicon as an ingredient and an impurity element are taken into a low-pressure reaction tube to make a polysilicon film containing an impurity on a high temperature substrate, a low-pressure CVD method characterized by causing the flow volume of the said impurity reaction gas to change during the formation of the impurity-added polysilicon film.

(2) The low-pressure CVD method described in Scope of Patent Application Item 1, which is characterized by causing the flow volume of the impurity-reaction gas to increase during formation of the impurity-added polysilicon film.

## 3. Detailed Explanation of Invention

This invention is one relating to a method of forming a polysilicon film to which an impurity is added by a low-pressure CVD method.

Usually, when making this kind of polysilicon film with impurity added, such reagent gases as silane ( $SiH_4$ ) and arsine ( $AsH_3$ ) are used with the flow volume of these reagent gases usually controlled by a mass controller.

Moreover, polysilicon silicon film made by such a method has such elements as phosphorus or arsenic distributed in it uniformly. As a result they have an isotropic nature with respect to etching or oxidation and so are inconvenient to use when one wants them to have a specific orientation in doing such processing as etching or oxidizing subsequent to their formation.

The goal of this invention is to provide a low-pressure CVD method that can form impurity-added polysilicon film with discretionary impurity concentration distributions in the thickness axis.

To achieve such a goal, the low-pressure CVD of this invention is one that alters the flow volume of impurity reaction gases during film-forming reactions to cope with prescribed concentration distributions. In the following we will use the figures to explain in detail the low-pressure CVD method from this invention.

The basic approach of causing chemical reactions by bringing the reaction gases at high temperatures into a reduced pressure reaction tube and laminating the polysilicon formed on the surface of a semiconductor substrate contained in the reaction tube is just the same as the ordinary low-pressure CVD method. In this instance, the silane gas flow volume is kept constant as usual by a mass controller. By contrast, we make the flow volume of the impurity reaction gas vary by electrically controlling the mass controller. For instance, by changing the flow volume of the impurity reaction gas from 0% silane to 1% silane, we can increase the impurity concentration up to about  $10^{21} \text{ cm}^{-3}$ . In this case, the component concentration with phosphine will change to 60% and with arsine to about 85%, but it has no great effect on the film's thickness distribution within a patch. I.e., by controlling the concentration of the impurity reaction gas, one can freely change the concentration of the impurity in the polysilicon film formed in the range of  $0 \sim 1.0^{21} \text{ cm}^{-3}$ .

When thus altering on the thickness axis the concentration of the contained impurity, the processing traits of the polysilicon film also will change accordingly. If the impurity concentration is altered within the above-described range, plasma etching speed, for instance, will change by 20 times and the oxidation speed by 10 times. Thus, later processing can be done easily by controlling in advance the concentration of the impurity content to match the kind of processing to be done on the polysilicon film produced.

Figure 1 is a trait graph showing the distribution of impurity concentrations in the usual polysilicon film containing an impurity, and also a cross-sectional diagram illustrating the progress of plasma etching in that case. On the surface of dielectric film (2) made on semiconductor substrate (1) is formed polysilicon film (3) with a uniform impurity distribution. If one forms resist (4) on a part of this polysilicon film (3) and does plasma etching, the etching will proceed almost uniformly because the impurity concentration is uniform; and a side-etched surface will be formed nearly perpendicular to the upper flat surface of said polysilicon film (3).

Figure 2 is a trait graph showing one example of the distribution of concentrations of the impurity contained in

polysilicon film from this invention's CVD method, and also a cross-sectional diagram illustrating the progress of plasma etching. We used the same keying symbols as in Figure 1 where the distribution is identical, and we omit any detailed explanation of that. In this instance, since the impurity concentration is greater the closer it is to the surface of polysilicon film (3) that was created, the faster the etching of the upper surface will proceed. So, compared to the case in Figure 1, a flat cross-sectional surface shape will be obtained, giving the advantage that when other layers are formed on this, more reliable density traits may be obtained.

Figure 3 is a trait diagram showing another case of the distribution of the impurity concentrations contained in a polysilicon film created when using the reduced-pressure CVD method of this invention, as well as a cross-sectional diagram of the situation where the upper part of polysilicon film (3) that has been formed is oxidized to form silicon oxide film (5). We use the same keying symbols for the parts identical to those in Figure 2, and will omit any detailed explanation of them. This is an example of keeping the flow volume of the impurity reaction gas at zero in forming a lower layer to be retained as polysilicon film (3) even after the oxidation process, and then inserting the impurity reaction gas only when forming the upper part to be oxidized. In this case, since the polysilicon with impurity added has quite a high oxide concentration compared to that without the impurity, it becomes possible to control with high precision the film thickness to which the oxidation will proceed.

As explained above, with the low-pressure CVD method of this invention one can freely alter--in the thickness axis-- the impurity concentration included in the polysilicon film created by altering the flow volume of the impurity reaction gas at the time the polysilicon film is created. So, controlling impurity concentration distributions according to the processing conditions to be applied to the polysilicon film produced has the excellent result of enabling one to precisely and easily do the prescribed processing.

#### **4. Simple Explanation of Figures**

Figure 1 is a cross-sectional graph showing polysilicon films formed by the usual low-pressure CVD method, and also

a trait diagram showing impurity concentrations included therein. Figure 2 is a cross-sectional diagram of a polysilicon film showing one application example of the low-pressure CVD method of this invention, and a trait diagram showing its impurity concentrations. Figure 3 is a cross-sectional diagram of a polysilicon film showing another application example of the low-pressure CVD method of this invention, and also a trait diagram showing its impurity concentrations.

## [keying Symbols]

- (1) ... Semiconductor substrate
- (2) ... Dielectric film
- (3) ... Polysilicon film
- (4) ... Resist
- (5) ... Silicon oxide film

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[In Figs. 1(a), 2(a) and 3(a) the horizontal axis is "Impurity concentration" and the vertical axis is "Thickness."]

Procedural Amendment  
(Self-initiated)

Jan. 29, 1981

TO: Director, Patent Office

1. Case indicated: 55-119971
2. Name of Invention: Low-pressure CVD Method
3. Person Making Amendment

Connection to Case: Patent applicant

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5. Amendment subject: Specification's detailed explanation of invention

(1) In line 10 of page 3, amend "1.0<sup>21</sup>"  
to "10<sup>21</sup>." [Line # and page # changed to match  
those of translated text.--Translator]